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# APPLIED HEALTH PHYSICS AND SAFETY
# ANNUAL REPORT FOR 1973

OAK RIDGE NATIONAL LABORATORY

OPERATED BY UNION CARBIDE CORPORATION • FOR THE U.S. ATOMIC ENERGY COMMISSION

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HEALTH PHYSICS DIVISION

# APPLIED HEALTH PHYSICS AND SAFETY ANNUAL REPORT FOR 1973

J. A. Auxier, Director

D. M. Davis, Assistant Director

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AUGUST 1974

OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee 37830
operated by
UNION CARBIDE CORPORATION
for the
U.S. ATOMIC ENERGY COMMISSION

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# FOREWORD

This report describes and summarizes the activities of the applied sections of the Health Physics Division, i.e., Radiation Monitoring, Radiation and Safety Surveys, and Safety Engineering and Special Projects for calendar year 1973. Projects and activities within the research sections are described in ORNL-4903, Health Physics Division Annual Progress Report, Period Ending July 31, 1973.

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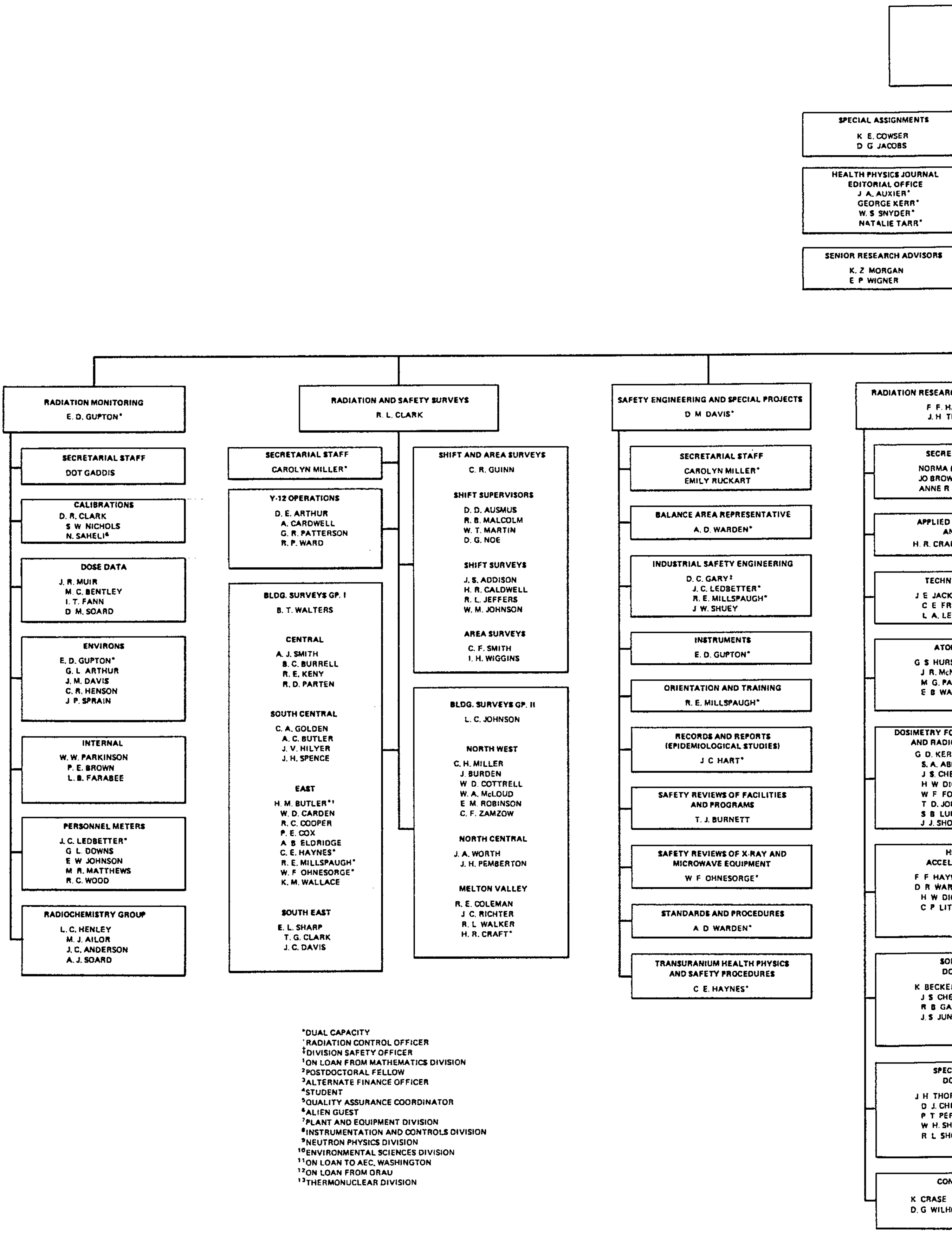


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# 2.0 SUMMARY

## RADIATION MONITORING

### Personnel Monitoring

There were no external or internal exposures to personnel which exceeded the standards for radiation protection as defined in AEC Manual Chapter 0524. Only 87 employees received an exposure greater than 1 rem. The highest whole body radiation dose for an employee was 4.63 rem. The highest internal exposure was about one-half of the maximum permissible body burden.

### Environs Monitoring

There were no releases of gaseous or liquid waste from the Laboratory which were of a level that required an incident report to the AEC. The average concentration of beta radioactivity in the atmosphere at the perimeter of the AEC-controlled area was less than one percent of the value applicable to releases to uncontrolled areas. The quantity of radionuclides of primary concern in the Clinch River averaged less than 0.5 percent of the $MPC_w$.

### Health Physics Instrumentation

During 1973, there were 31 portable instruments added to the inventory and 41 retired. The total number in service on January 1, 1974, was 1,283. There were two facility radiation monitoring instruments installed and 14 retired during 1973. The total number in service on January 1, 1974, was 982.

## RADIATION AND SAFETY SURVEYS

### Laboratory Operations Monitoring

During 1973, the Radiation and Safety Surveys personnel continued to assist the operating groups in keeping the contamination, air concentration and personnel exposure levels below the established maximum permissible levels. They assisted in reducing or eliminating a number of problems associated with radiation protection at the Laboratory.

### Unusual Occurrences

Ten unusual occurrences involving radioactive materials were recorded during 1973. The number reported for 1972 was 11, and the average number for the past five years (1969-1973) was 10.4.

### Laundry Monitoring

Of the 337,300 articles of wearing apparel monitored during 1973, about 14 percent were found contaminated.

## SAFETY ENGINEERING AND SPECIAL PROJECTS

### Accident Analyses

There were two Disabling Injuries experienced at ORNL in 1973, a frequency rate of 0.33. This is the lowest frequency rate reported since 1969 when the frequency rate was 0.27. There were two Disabling Injuries in 1969 as in 1973, but the total labor hours for the Laboratory was less in 1973 than in 1969.

### Summary of Disabling Injuries

One of the Disabling Injuries in 1973 occurred when a carpenter fell from a stepladder. The other injury occurred when an equipment operator struck a fence post while mowing with a farm-type tractor.

### Safety Awards

ORNL employees worked three award periods of 120 days without a Disabling Injury.

## INFORMATIONAL ACTIVITIES

### Visitors and Training Groups

During 1973, there were 98 visitors to the Applied Health Physics and Safety Sections for training purposes. There were four groups of four or more persons.

# 3.0 RADIATION MONITORING

## 3.1 Personnel Monitoring

All persons who enter Laboratory areas where there is a likelihood of exposure to radiation or radioactive materials are monitored for the kinds of exposure they are likely to sustain. External radiation dosimetry is accomplished mainly by means of badge-meters, pocket ion chambers, and hand exposure meters. Internal exposure is determined from bio-assays and in vivo counting.

### 3.1.1 Dose Analysis Summary, 1973

(a) External Exposures - No employee received a whole body radiation dose which exceeded the standards for radiation protection, AEC Manual Chapter 0524. The maximum whole body exposure dose received by an employee was about 4.63 rem or 39 percent of the maximum permissible annual dose. The range of doses to persons using ORNL badge-meters is shown in Table 3.1.1, page 13.

As of December 31, 1973, no employee had a cumulative whole body dose which was greater than the recommended maximum permissible value based on the age proration formula 5(N-18) (Table 3.1.2, page 13). No employee had an average annual exposure rate that exceeded 5 rem per year of employment (Table 3.1.3, page 13). The greatest cumulative dose of whole body radiation received by an employee was approximately 102 rem. This dose was accrued over an employment period of about 30 years and represents an average exposure of about 3.4 rem per year.

The greatest cumulative dose to the skin of the whole body received by an employee during 1973 was about 8.4 rem or 28 percent of the maximum permissible annual skin dose of 30 rem.

The maximum cumulative hand exposure recorded during 1973 was about 19 rem or 25 percent of the recommended maximum permissible annual dose to the extremities.

The average of the 10 greatest whole body doses to ORNL employees for each of the years 1969 through 1973 is shown in Table 3.1.4, page 14. The maximum individual dose for each of those years is shown, also.

(b) Internal Exposures - No employee received an internal radiation dose which exceeded the standards for radiation protection, AEC Manual Chapter 0524. There was only one case of internal exposure for which the deposition of radioactive materials within the body may have averaged as much as one-half of the maximum permissible body burden for the year.

Four employees have estimated body burdens of transuranic alpha emitters slightly less than 50 percent of the recommended maximum permissible value.[1] The ICRP recommends, Publication 6, paragraph 86(a), that individuals who exceed 50 percent of a maximum permissible body burden be placed on a work assignment where the potential for internal exposure is reduced.

3.1.2 External Dose Techniques

(a) Badge-Meters - Badge-meters are issued to all persons who have access to ORNL facilities in which there is a likelihood of radiation exposures for which monitoring is required. Photo-badge-meters are assigned to all ORNL employees and to certain other persons who are authorized to enter ORNL facilities. Temporary meters may be issued in lieu of photo-badge-meters for short-term use.

NTA (nuclear track) film packets are included in all film meters. The NTA films are processed routinely if the badge-meter is assigned to an individual who normally works where there may be exposure to neutrons; otherwise the films would be processed only in the event of a nuclear accident.

Beta-gamma sensitive films from badge-meters issued to full-time employees are processed routinely each calendar quarter (or more frequently, if necessary). Films used in other meters are processed as conditions of use may require. Films from meters issued to visitors are processed if there is a likelihood that a radiation exposure was incurred.

High-level radiation dosimetry components of the badge-meters (sulfur, gold, indium, and metaphosphate glass) are for use in the event that doses exceed the capability of the monitoring films.

Thermoluminescent dosimeters, TLD-100 ribbons, are included in badge-meters of persons who are likely to sustain significant exposures, particularly to lower energy photons.

(b) Pocket Meters - Pocket meters (indirect reading, ionization chambers) are made available at all principal points of entry to ORNL premises. A pair of pocket meters is carried for the duration of a work shift by persons who work in an area where the potential for an exposure of 20 mR or more exists during the work shift. Pocket meter pairs are processed each day by Health Physics technicians and readings of 20 mR or more are reported daily to supervision. Pocket meters are used for a day-to-day record of integrated exposure.

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[1] AEC Manual Chapter 0502 requires an evaluation of the radiation exposure status of an employee when monitoring techniques indicate that a body burden equals or exceeds 50 percent of a maximum permissible limit.

(c) Hand Exposure Meters - Hand exposure meters are TLD-loaded finger rings used to measure hand exposure. Hand exposure meters are issued to persons for use during operations where it is likely that the hand dose is such as to exceed 1 rem during the week. They are issued and collected by Radiation and Safety Surveys personnel who determine the need for this type of monitoring and arrange for a processing schedule.

(d) Metering Résumé - Shown in Table 3.1.5, page 15, are the quantities of personnel metering devices used and processed during 1973. The number of films processed is less than the number issued, because those which are issued for accident dosimetry only are not processed unless there is a likelihood of exposure.

3.1.3 Internal Dose Techniques

(a) Bio-Assay - Urine and fecal samples are analyzed for the purpose of making internal dose determinations. The frequency of sampling and the type of radiochemical analysis performed are based upon each specific radioisotope and the exposure potential. Because of the small quantities of radioactive material in most samples, qualitative analyses are not feasible, and only quantitative analyses for predetermined isotopes are performed routinely.

In most cases bio-assay data require interpretation to determine the dose to the person; computer programs are used for evaluation of extensive data on urinary excretion of $^{239}$Pu. An estimate of dose is made for all cases in which it appears that one-fourth of a body burden, averaged over a calendar year, may be exceeded.

The analyses performed by the Applied Health Physics and Safety Radiochemical Lab during 1973 are summarized in Table 3.1.6, page 16.

(b) Whole Body Counter - The Whole Body Counter (an in vivo gamma spectrometer) may be used for determining internally deposited quantities of most radionuclides which emit photons.

During the calendar year 1973 there were 350 whole body or thorax counts of ORNL employees. No detectable activity of significance relatable to ORNL exposure was found.

(c) Counting Facility - The Applied Health Physics and Safety counting facility determines radioactivity content of samples submitted by groups within the Department. A summary of analyses is in Table 3.1.7, page 17.

3.1.4 Reports

Routine reports of personnel monitoring data are prepared and distributed to divisional supervision and to Applied Health Physics and Safety staff.

(a) Pocket Meter Data - A report is prepared daily of the names, ORNL division, and readings for pocket meter readings which were 20 mR or greater during the previous 24 hours.

A computer-prepared report, which includes all pocket meter data for the previous week, and summary data for the calendar quarter, is published and distributed weekly.

(b) External Dosimetry Data - A computer-prepared report, which includes data of recorded skin dose and whole body dose for the previous calendar quarter and totals for the current year, is published and distributed quarterly.

(c) Bio-Assay Data - A computer-prepared report, which includes data of sample status and results for the previous week, is published and distributed weekly. A quarterly and an annual report of results are prepared and distributed.

(d) Whole Body Counter Data - Preliminary results of analysis are reported on a card form soon after counting is done.

A computer-prepared report, which includes data collected during the previous calendar quarters of the calendar year, is published and distributed quarterly.

#### 3.1.5 Records

Permanent records of personnel monitoring data are maintained for each person who is assigned an ORNL photo-badge-meter.

### 3.2 Environs Monitoring

The Health Physics Division monitors for airborne radioactivity in the East Tennessee area by the use of three separate monitoring networks. The local air monitoring (LAM) network consists of 22 stations which are positioned in the vicinity of ORNL operational activities; the perimeter air monitoring (PAM) network consists of nine stations which are located near the perimeter of the AEC-controlled area; and the remote air monitoring (RAM) network consists of eight stations which are located outside the AEC-controlled area at distances of from 12 to 75 miles from ORNL.[2] The monitoring networks provide for the collection of (1) airborne radioactivity by air filtration techniques, (2) radioparticulate fallout material by impingement on gummed paper trays, and (3) rainwater for measurement of fallout occurring as rainout.

Low-level radioactive liquid wastes originating from ORNL operations are discharged, after preliminary treatment, to White Oak Creek, which is a small tributary

[2] For maps showing location of station, see ORNL-4423, Applied Health Physics and Safety Annual Report for 1968.

of the Clinch River. The radioactive content of White Oak Creek discharge is determined at White Oak Dam which is the last control point along the stream prior to entry of White Oak Creek waters into Clinch River waters. Water samples are collected also at a number of locations along the Clinch River, beginning at a point above the entry of waste into the River via White Oak Creek and ending at Center's Ferry (near Kingston, Tennessee) about 16 miles downstream from the confluence of White Oak Creek and the Clinch River. Water samples are analyzed for gross radioactivity and for specific radionuclides present in detectable quantities. The concentration of each nuclide detected is compared with its respective $MPC_w$ value, as specified by AEC Manual Chapter 0524, and the resulting fractions summed to arrive at the percent $MPC_w$ in the Clinch River.

Samples of ORNL potable water are collected daily, composited and stored. At the end of each quarter these composites are analyzed radiochemically for $^{90}Sr$ content and are assayed for long-lived gamma-emitting radionuclides by gamma spectrometry.

Raw milk samples are collected at 12 sampling stations located within a radius of 50 miles from ORNL. Samples are taken on a weekly basis from eight stations which are located outside the AEC-controlled area within a 12-mile radius of ORNL. Samples are collected every five weeks from the four remaining stations, all of which are located outside the 12-mile radius up to distances of about 50 miles. The purpose of the milk sampling program is twofold: first, samples collected in the immediate vicinity of ORNL provide data by which one may evaluate the possible effect of waste releases originating from ORNL operations; second, samples collected remote to the immediate vicinity of ORNL provide background data which are essential in establishing a proper index from which releases of radioactive materials originating from Oak Ridge operations may be evaluated.

Background gamma radiation measurements are made at a number of locations in the East Tennessee area. These measurements are taken with thermoluminescent detectors at a distance of four feet above the surface of the ground.

Fish from the Clinch River are sampled during the spring and summer and analyzed for their radioactive content. The radionuclide concentrations in fish are related quantitatively to potential human intake of radioactivity through consumption of fish.

3.2.1 Atmospheric Monitoring

(a) Air Concentrations - The average concentrations of beta radioactivity in the atmosphere, as measured with filters from the LAM, PAM, and RAM networks during 1973, were as follows:

| Network | Concentration (μCi/cc) |
|---|---|
| LAM | $6.5 \times 10^{-14}$ |
| PAM | $2.9 \times 10^{-14}$ |
| RAM | $2.8 \times 10^{-14}$ |

The LAM network value of $6.5 \times 10^{-14}$ μCi/cc is less than 0.01 percent of the $MPCU_a$[3] based on occupational exposure of $3 \times 10^{-9}$ μCi/cc. Both the PAM and RAM network values represent < 0.1 percent of the $MPCU_a$ of $1 \times 10^{-10}$ μCi/cc applicable to releases to uncontrolled areas. A tabulation of data for each station in each network is given in Table 3.2.1, page 18. The weekly values for each network are illustrated in Table 3.2.2, page 19.

(b) Fallout (Gummed Paper Technique) - The number of particles observable by autoradiography were fewer in 1973 than in 1972. The average activity and observable particles per square foot for the stations are shown in Table 3.2.3, page 20.

(c) Rainout (Gross Analysis of Rainwater) - The average concentration of radioactivity in rainwater collected from the three networks during 1973 was as follows:

| Network | Concentration (μCi/cc) |
|---|---|
| LAM | $0.8 \times 10^{-8}$ |
| PAM | $1.0 \times 10^{-8}$ |
| RAM | $1.2 \times 10^{-8}$ |

The average concentration in each network was about one-half the values observed during 1972. The average concentration measured at each station within each network is presented in Table 3.2.4, page 21. The average concentration for each network for each week is given in Table 3.2.5, page 22.

(d) Atmospheric Radioiodine (Charcoal Cartridge Technique) - Atmospheric iodine sampled at the perimeter stations averaged $0.9 \times 10^{-14}$ μCi/cc during 1973. This average represents about 0.01 percent of the maximum permissible inhalation concentration of $1 \times 10^{-10}$ μCi/cc applicable to $^{131}I$ released to uncontrolled areas.

[3] The $MPCU_a$ is defined as the maximum permissible concentration for an unknown mixture of radioisotopes in air. AEC Manual Chapter 0524, Appendix, Annex 1, gives exposure values applicable to various mixtures of radionuclides and establishes guidelines for deriving the $MPCU_a$.

The maximum concentration observed at any one station for one week was $4.8 \times 10^{-14}$ μCi/cc, at PAM 35, the perimeter station located at Blair Gate.

The average radioiodine concentration at the local stations was $4.7 \times 10^{-14}$ μCi/cc. This concentration is less than 0.01 percent of the maximum permissible inhalation concentration for occupational exposure. The maximum concentration at any one station for one week was $50 \times 10^{-14}$ μCi/cc, at LAM 10 located west of the lower tank farm.

Table 3.2.6, page 23, presents the $^{131}I$ weekly average concentration data for both the local area (LAM) and the perimeter area (PAM) air monitoring networks.

(e) Milk Analysis - The average concentration of $^{131}I$ in raw milk samples collected near ORNL (within 12-mile radius) during 1973 ranged between 0.0 and 10.1 pCi/l and the average of samples collected from stations located more remotely from ORNL ranged between 0 and 10 pCi/l. The upper and lower limits of the average values were obtained by equating all values which were less than the minimum detectable level, 10 pCi/l, to zero for the lower limit and to 10 pCi/l for the upper limit. Table 3.2.7, page 24, gives the quarterly average and maximum values obtained from samples collected near ORNL and remote from ORNL.

The average concentration of $^{90}Sr$ in raw milk samples collected near ORNL was 8.1 pCi/l. The average concentration in the samples collected remote from ORNL was 6.1 pCi/l. Table 3.2.8, page 24, presents the quarterly average and maximum values obtained from both sampling areas.

The yearly average values for both $^{131}I$ and $^{90}Sr$ fall within the limits of FRC Range I daily intake guides, if one assumes an intake of 1 liter of milk per day.

(f) ORNL Stack Releases - The $^{131}I$ releases from ORNL stacks are summarized in Table 3.2.9, page 25.

3.2.2 Water Monitoring

(a) White Oak Lake Waters - A total of 15,000 curies of tritium and about 11 beta curies of radioactivity other than tritium were released to the Clinch River during 1973 as compared with 11,000 curies of tritium and 8.8 beta curies of other radionuclides released in 1972. Yearly discharges of specific radionuclides to the Clinch River, 1968 through 1973, are shown in Table 3.2.10, page 26.

The calculated average concentrations of the significant radionuclides in the Clinch River at Clinch River Mile (CRM) 20.8 (the point of entry of White Oak Creek into the River) are presented in Table 3.2.11, page 27. The percent $MPC_w$ did not exceed 1.1 percent for any month during 1973 (Table 3.2.12, page 28).

(b) Clinch River Water – The measured average concentrations and the percent of $MPC_w$ of radionuclides in the Clinch River at Melton Hill Dam (CRM 23.1), about three miles upstream, at Gallaher (CRM 14.5), about six miles downstream, and at Center's Ferry (CRM 4.5), about 16 miles downstream from the entry of White Oak Creek, are given in Table 3.2.11, page 27.

(c) Potable Water – The average concentrations of $^{90}Sr$ in potable water at ORNL during 1973 were as follows:

| Quarter Number | Concentration of $^{90}Sr$ (μCi/ml) |
|---|---|
| 1 | $4.0 \times 10^{-10}$ |
| 2 | $2.7 \times 10^{-10}$ |
| 3 | $4.5 \times 10^{-10}$ |
| 4 | $6.3 \times 10^{-10}$ |
| Average for year | $4.4 \times 10^{-10}$ |

The average value of $4.4 \times 10^{-10}$ represents 0.14 percent of the $MPC_w$ for drinking water applicable to individuals in the general population. This $^{90}Sr$ concentration is about the same as that in Melton Hill Lake (Table 3.2.11, page 27) which is the source of this potable water.

(d) Radionuclides in Clinch River Fish – Several species of fish were sampled from the Clinch River during the spring and summer of 1973. The fish were prepared for radiochemical analysis in a manner analogous to human utilization. Ten fish of each species were composited and the samples were analyzed, by gamma spectrometry and radiochemical techniques, for the critical radionuclides contributing significantly to the potential radiation dose to man. The data are tabulated in pCi/kg of wet weight (Table 3.2.13, page 29) for each radionuclide of significance. An estimate of man's intake of radionuclides from eating the fish is made by assuming an annual rate of fish consumption of 14 pounds. An estimated percentage of maximum permissible intake is calculated by assuming a maximum permissible intake of fish to be comparable to a daily intake of 2.2 liters of water containing the $MPC_w$ of these radionuclides for a period of one year.

### 3.2.3 Background Measurements

Background measurements were made at the PAM and RAM stations. The average background level during 1973, as measured at these stations, was 7.8 μR/hr. Average background readings for each station are presented in Table 3.2.14, page 30.

### 3.2.4 Environmental Monitoring Samples

A listing of environmental monitoring samples processed by type sample, type of analyses, and number of samples is given in Table 3.2.15, page 31.

## 3.3 Health Physics Instrumentation

The Health Physics Division shares with the Instrumentation and Controls Division the responsibility for the selection of electronic radiation monitoring instruments used in the ORNL health physics program. Normally, the Health Physics Division is responsible for determining the need for new instrument types and modifications to existing types, for specifying the health physics requirements, and for approval of the design. The Health Physics Division is also responsible for calibrating all instruments used in the health physics program and is allocated the funds for maintenance of these instruments. Maintenance is performed or cross-ordered by the Instrumentation and Controls Division.

Non-electronic personnel monitoring devices are designed, tested, calibrated and maintained by Health Physics Division personnel.

### 3.3.1 Instrument Inventory

The electronic instruments used in the health physics program are divided, for convenience in servicing and calibrating, into two classes: the first class includes battery-powered portable instruments; the second class includes the stationary instruments that are AC powered. Portable instruments are assigned and issued to the Radiation and Safety Surveys Complexes. Stationary instruments are the property of the ORNL division which has the monitoring responsibility in the area in which the instrument is located. Table 3.3.1, page 32, lists portable instruments assigned at the end of 1973; Table 3.3.2, page 32, lists stationary instruments at the X-10 site in use at the end of 1973.

There was a decrease of 12 stationary instruments and a decrease of 10 portable instruments during the year.

Inventory and Service Summaries for health physics instruments are prepared on an IBM 360. These computer-programmed reports enable the Instruments Group to maintain a current inventory on most health physics instrument requirements.

The allocation of stationary health physics monitoring instruments at the X-10 site by division is shown in Table 3.3.3, page 33.

3.3.2 Calibration Facility

The Health Physics Division maintains a calibration facility for the calibration and maintenance of portable radiation instruments and personnel metering devices. The facility is equipped with calibration sources, remote control devices, and shop space for the use of Instrumentation and Controls Division maintenance personnel. Health Physics personnel assign, arrange for maintenance of, calibrate, provide delivery services for, and maintain inventory and servicing data of all portable health physics instruments.

Portable instruments should be serviced (1) whenever repairs are needed, (2) at least once each two months for those which have replacement-type batteries, and (3) at least once each three months for those instruments which have "permanent" (rechargeable) batteries. The number of calibrations of portable instruments for 1973 is shown in Table 3.3.4, page 34.

Table 3.1.1 Dose Data Summary for Laboratory Population Involving Exposure to Whole Body Radiation—1973

| Group | Number of Rem Doses in Each Range | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|
| | 0-1 | 1-2 | 2-3 | 3-4 | 4-5 | 5-6 | 6 up | |
| ORNL Employees | 4629 | 66 | 17 | 3 | 1 | 0 | 0 | 4716 |
| ORNL-Monitored Non-Employees | 64 | 0 | 0 | 0 | 0 | 0 | 0 | 64 |
| TOTAL | 4693 | 66 | 17 | 3 | 1 | 0 | 0 | 4780 |

Table 3.1.2 Average Rem Per Year Since Age 18—1973

| Group | Number of Doses in Each Range | | | | Total |
|---|---|---|---|---|---|
| | 0-2.5 | 2.5-5.0 | 5.0-7.5 | 7.5 up | |
| ORNL Employees | 4710 | 6 | 0 | 0 | 4716 |

Table 3.1.3 Average Rem Per Year of Employment at ORNL—1973

| Group | Number of Doses in Each Range | | | | Total |
|---|---|---|---|---|---|
| | 0-2.5 | 2.5-5.0 | 5.0-7.5 | 7.5 up | |
| ORNL Employees | 4703 | 13 | 0 | 0 | 4716 |

Table 3.1.4 Average of the Ten Highest Whole Body Doses and the Highest Individual Dose by Year

| Year | Average of the Ten Highest Doses (Rem) | The Highest Dose (Rem) |
|---|---|---|
| 1969 | 2.84 | 3.79 |
| 1970 | 2.79 | 4.04 |
| 1971 | 3.41 | 4.95 |
| 1972 | 4.18 | 4.88 |
| 1973 | 3.12 | 4.63 |

Table 3.1.5 Personnel Meter Services

| | 1971 | 1972 | 1973 |
|---|---|---|---|
| A. Pocket Meter Usage | | | |
| 1. Number of Pairs Used | | | |
| ORNL | 96,668 | 79,976 | 75,888 |
| CPFF | 8,528 | 3,796 | 6,032 |
| Total | 105,196 | 83,772 | 81,920 |
| 2. Average Number of Users per Quarter | | | |
| ORNL | 907 | 915 | 753 |
| CPFF | 132 | 86 | 96 |
| Total | 1,039 | 1,001 | 849 |
| B. Film Usage | | | |
| 1. Films Used in Photo-Badge-Meters | | | |
| Beta-Gamma | 18,400 | 18,100 | 19,220 |
| NTA | 9,110 | 8,960 | 9,410 |
| 2. Films Used in Temporary Meters | | | |
| Beta-Gamma | 6,700 | 5,810 | 5,080 |
| NTA | 2,170 | 1,880 | 1,460 |
| C. Films Processed for Monitoring Data | | | |
| 1. Beta-Gamma | 19,500 | 19,050 | 19,430 |
| 2. NTA | 1,110 | 1,250 | 1,390 |
| 3. Hand Meter | 1,480 | 700 | 1,400 |

Table 3.1.6 Radiochemical Lab Analyses—1973

| Radionuclide | Urine | Feces | Milk | Soil | Other | Controls |
|---|---|---|---|---|---|---|
| Plutonium, Alpha | 800 | 3 | | 18 | | 250 |
| Transplutonium, Alpha | 680 | 2 | | | | 250 |
| Uranium, Alpha | 330 | 1 | | 18 | | 50 |
| Strontium, Beta | 496 | 1 | 428 | | | 50 |
| Cesium-137 | 102 | | | | | |
| Tritium | 78 | | | | | 25 |
| Iodine-131 | | | 428 | | | 50 |
| Other | 279 | | | | 50 | |
| TOTALS | 2687 | 7 | 856 | 36 | 50 | 675 |

Table 3.1.7 Counting Facility Analyses—1973

| Types of Samples | Number of Samples | | | Unit Total |
|---|---|---|---|---|
| | Alpha | Beta | Gamma | |
| **Facility Monitoring** | | | | |
| Smears | 51,905 | 53,312 | | 105,217 |
| Air Filters | 14,842 | 13,512 | | 28,354 |
| **Environs Monitoring** | | | | |
| Air Filters | 3,022 | 3,022 | | 6,044 |
| Fallout | | 2,979 | | 2,979 |
| Rainwater | | 758 | | 758 |
| Surface Water | | 156 | | 156 |
| Milk | | | 355 | 355 |

Table 3.2.1 Concentration of Beta Radioactivity in Air—1973
(Filter Paper Data—Weekly Average)

| Station Number | Location | Long-Lived Activity $10^{-14}$ μCi/cc |
|---|---|---|
| | Laboratory Area | |
| HP-1 | S 3587 | 4.1 |
| HP-2 | NE 3025 | 6.6 |
| HP-3 | SW 1000 | 4.6 |
| HP-4 | W Settling Basin | 5.9 |
| HP-5 | E 2506 | 23.0 |
| HP-6 | SW 3027 | 5.2 |
| HP-7 | W 7001 | 4.0 |
| HP-8 | Rock Quarry | 4.3 |
| HP-9 | N Bethel Valley Road | 4.3 |
| HP-10 | W 2075 | 5.3 |
| HP-16 | E 4500 | 5.1 |
| HP-20 | HFIR | 5.3 |
| Average | | 6.5 |
| | Perimeter Area | |
| HP-31 | Kerr Hollow Gate | 2.6 |
| HP-32 | Midway Gate | 3.1 |
| HP-33 | Gallaher Gate | 2.5 |
| HP-34 | White Oak Dam | 2.7 |
| HP-35 | Blair Gate | 3.4 |
| HP-36 | Turnpike Gate | 3.6 |
| HP-37 | Hickory Creek Bend | 2.4 |
| HP-38 | E EGCR | 2.5 |
| HP-39 | Townsite | 2.9 |
| Average | | 2.9 |
| | Remote Area | |
| HP-51 | Norris Dam | 2.7 |
| HP-52 | Loudoun Dam | 2.7 |
| HP-53 | Douglas Dam | 2.8 |
| HP-54 | Cherokee Dam | 2.8 |
| HP-55 | Watts Bar Dam | 2.9 |
| HP-56 | Great Falls Dam | 2.6 |
| HP-57 | Dale Hollow Dam | 2.5 |
| HP-58 | Knoxville | 2.5 |
| Average | | 2.8 |

Table 3.2.2 Concentration of Beta Radioactivity in Air as Determined from Filter Paper Data—1973 (System Average - by Weeks)

| Week Number | Units of $10^{-14}$ µCi/cc | | | Week Number | Units of $10^{-14}$ µCi/cc | | |
|---|---|---|---|---|---|---|---|
| | LAM's | PAM's | RAM's | | LAM's | PAM's | RAM's |
| 1 | 1.8 | 0.6 | 0.6 | 29 | 6.4 | 3.6 | 3.4 |
| 2 | 5.6 | 3.6 | 2.4 | 30 | 5.4 | 3.2 | 2.9 |
| 3 | 3.4 | 2.2 | 1.1 | 31 | 4.7 | 3.0 | 3.1 |
| 4 | 2.0 | 1.4 | 0.8 | 32 | 5.2 | 2.0 | 2.6 |
| 5 | 3.0 | 2.0 | 1.0 | 33 | 5.3 | 2.6 | 2.9 |
| 6 | 4.5 | 2.1 | 2.3 | 34 | 5.8 | 3.9 | 3.7 |
| 7 | 3.7 | 2.1 | 2.5 | 35 | 10.2 | 5.5 | 4.6 |
| 8 | 4.2 | 3.0 | 3.1 | 36 | 7.8 | 3.2 | 3.7 |
| 9 | 10.0 | 2.4 | 2.8 | 37 | 6.3 | 3.6 | 3.6 |
| 10 | 10.0 | 2.2 | 2.1 | 38 | 6.7 | 4.0 | 3.7 |
| 11 | 11.8 | 2.5 | 2.4 | 39 | 6.7 | 2.2 | 2.8 |
| 12 | 3.2 | 1.6 | 2.3 | 40 | 5.1 | 3.1 | 3.1 |
| 13 | 2.6 | 1.7 | 1.6 | 41 | 7.3 | 4.0 | 3.7 |
| 14 | 6.8 | 1.9 | 1.9 | 42 | 5.3 | 3.1 | 3.0 |
| 15 | 21.7 | 1.6 | 1.5 | 43 | 9.2 | 4.2 | 3.7 |
| 16 | 19.9 | 3.2 | 2.8 | 44 | 4.7 | 3.7 | 3.2 |
| 17 | 13.0 | 3.0 | 2.1 | 45 | 5.3 | 3.2 | 3.1 |
| 18 | 6.7 | 4.0 | 3.6 | 46 | 6.5 | 2.8 | 3.1 |
| 19 | 4.8 | 3.2 | 2.7 | 47 | 14.1 | 3.5 | 3.6 |
| 20 | 3.9 | 2.5 | 2.7 | 48 | 4.4 | 3.0 | 2.7 |
| 21 | 4.1 | 2.3 | 2.2 | 49 | 5.2 | 3.2 | 3.2 |
| 22 | 5.3 | 3.3 | 2.3 | 50 | 3.6 | 2.1 | 2.5 |
| 23 | 3.7 | 1.9 | 1.9 | 51 | 5.1 | 2.4 | 2.5 |
| 24 | 5.5 | 3.1 | 2.0 | 52 | 3.7 | 2.1 | 2.2 |
| 25 | 3.2 | 1.7 | 1.8 | | | | |
| 26 | 7.3 | 3.0 | 3.1 | | | | |
| 27 | 4.4 | 3.0 | 2.9 | | | | |
| 28 | 12.5 | 6.4 | 4.7 | Average | 6.5 | 2.9 | 2.7 |

Table 3.2.3 Radioparticulate Fallout—1973
(Gummed Paper Data—Station Weekly Average)

| Station Number | Location | Long-Lived Beta Activity $10^{-4}$ $\mu Ci/ft^2$ | Total[a] Particles Per Sq. Ft. |
|---|---|---|---|
| | **Laboratory Area** | | |
| HP-1 | S 3587 | 0.26 | 0.12 |
| HP-2 | NE 3025 | 0.27 | 0.60 |
| HP-3 | SW 1000 | 0.11 | 0 |
| HP-4 | W Settling Basin | 0.17 | 0.10 |
| HP-5 | E 2506 | 0.17 | 0.17 |
| HP-6 | SW 3027 | 0.15 | 0.23 |
| HP-7 | W 7001 | 0.17 | 0.02 |
| HP-8 | Rock Quarry | 0.11 | 0 |
| HP-9 | N Bethel Valley Road | 0.12 | 0 |
| HP-10 | W 2075 | 0.27 | 0.23 |
| HP-16 | E 4500 | 0.13 | 0 |
| HP-20 | HFIR | 0.11 | 0 |
| Average | | 0.17 | 0.12 |
| | **Perimeter Area** | | |
| HP-31 | Kerr Hollow Gate | 0.12 | 0 |
| HP-32 | Midway Gate | 0.13 | 0 |
| HP-33 | Gallaher Gate | 0.11 | 0 |
| HP-34 | White Oak Dam | 0.10 | 0 |
| HP-35 | Blair Gate | 0.11 | 0.08 |
| HP-36 | Turnpike Gate | 0.11 | 0 |
| HP-37 | Hickory Creek Bend | 0.11 | 0.02 |
| HP-38 | E EGCR | 0.13 | 0 |
| HP-39 | Townsite | 0.11 | 0 |
| Average | | 0.12 | 0.01 |
| | **Remote Area** | | |
| HP-51 | Norris Dam | 0.10 | 0 |
| HP-52 | Loudoun Dam | 0.11 | 0 |
| HP-53 | Douglas Dam | 0.11 | 0 |
| HP-54 | Cherokee Dam | 0.09 | 0 |
| HP-55 | Watts Bar Dam | 0.09 | 0 |
| HP-56 | Great Falls Dam | 0.10 | 0 |
| HP-57 | Dale Hollow Dam | 0.10 | 0 |
| HP-58 | Knoxville | 0.11 | 0 |
| Average | | 0.10 | 0 |

[a]Detection limit - $10^4$ d/24 hr. per particle by autoradiographic technique.

Table 3.2.4 Concentration of Beta Radioactivity in Rainwater—1973
(Weekly Average by Stations)

| Station Number | Location | Activity in Collected Rainwater, $10^{-8}$ μCi/ml |
|---|---|---|
| | Laboratory Area | |
| HP-7 | West 7001 | 0.8 |
| | Perimeter Area | |
| HP-31 | Kerr Hollow Gate | 0.9 |
| HP-32 | Midway Gate | 1.0 |
| HP-33 | Gallaher Gate | 1.1 |
| HP-34 | White Oak Dam | 1.1 |
| HP-35 | Blair Gate | 1.0 |
| HP-36 | Tumpike Gate | 0.8 |
| HP-37 | Hickory Creek Bend | 0.9 |
| HP-38 | E EGCR | 1.1 |
| HP-39 | Townsite | 1.0 |
| Average | | 1.0 |
| | Remote Area | |
| HP-51 | Norris Dam | 1.3 |
| HP-52 | Loudoun Dam | 1.6 |
| HP-53 | Douglas Dam | 1.0 |
| HP-54 | Cherokee Dam | 1.3 |
| HP-55 | Watts Bar Dam | 1.2 |
| HP-56 | Great Falls Dam | 1.3 |
| HP-57 | Dale Hollow Dam | 0.8 |
| HP-58 | Knoxville | 1.0 |
| Average | | 1.2 |

Table 3.2.5 Weekly Average Concentration of Beta Radioactivity in Rainwater—1973 (Units of $10^{-8}$ μCi/ml)

| Week Number | LAM's | PAM's | RAM's | Week Number | LAM's | PAM's | RAM's |
|---|---|---|---|---|---|---|---|
| 1 | 0 | 0.7 | 0.6 | 29 | ★ | ★ | 3.7 |
| 2 | 1.2 | 0.5 | 0.9 | 30 | 1.1 | 1.8 | 2.1 |
| 3 | 0 | 0.3 | 0.8 | 31 | 0 | 1.5 | 0.6 |
| 4 | 0.1 | 0.1 | 0.3 | 32 | 1.7 | 1.0 | 1.0 |
| 5 | 0.7 | 0.6 | 0.3 | 33 | 0 | 1.6 | 2.3 |
| 6 | 0 | 0.8 | 1.2 | 34 | 0.6 | ★ | 2.3 |
| 7 | 0.9 | 0.4 | 0.6 | 35 | ★ | ★ | 0 |
| 8 | ★ | ★ | 0 | 36 | 0.8 | 1.1 | 1.6 |
| 9 | 0.4 | 0.7 | 0.8 | 37 | 0 | 0.8 | 0.5 |
| 10 | 0 | 0.7 | 0.6 | 38 | ★ | 0 | 1.8 |
| 11 | 0.9 | 0.6 | 0.3 | 39 | 0.9 | 0.5 | 1.1 |
| 12 | 1.4 | 1.5 | 1.9 | 40 | ★ | ★ | 0.9 |
| 13 | 0.6 | 0.7 | 1.3 | 41 | 0 | 0.2 | 1.0 |
| 14 | 0.8 | 0.1 | 0.2 | 42 | ★ | ★ | ★ |
| 15 | ★ | ★ | 1.5 | 43 | 0.5 | 0.4 | 0.5 |
| 16 | 0 | 0 | 0 | 44 | 2.1 | 1.4 | 2.2 |
| 17 | 1.2 | 1.2 | 1.4 | 45 | ★ | ★ | 0.5 |
| 18 | 1.4 | 0.7 | 1.0 | 46 | 0.5 | 0.6 | 1.0 |
| 19 | 0.9 | 1.5 | 1.6 | 47 | 1.2 | 0.7 | 0.8 |
| 20 | 1.2 | 1.1 | 1.2 | 48 | 0.6 | 0.3 | 0.6 |
| 21 | ★ | 1.3 | 1.0 | 49 | 1.0 | 1.0 | 1.9 |
| 22 | ★ | ★ | 1.7 | 50 | 1.9 | 2.1 | 3.8 |
| 23 | 0.6 | 0.6 | 1.2 | 51 | 0.6 | 1.3 | 1.6 |
| 24 | 0 | 0.7 | 1.1 | 52 | 2.5 | 2.1 | 2.6 |
| 25 | 0.1 | 1.5 | 1.7 | | | | |
| 26 | 1.1 | 1.2 | 1.7 | | | | |
| 27 | 1.7 | 1.9 | 2.4 | | | | |
| 28 | 2.3 | 2.3 | 3.4 | Average | 0.8 | 1.0 | 1.2 |

★No rainfall.

Table 3.2.6 Weekly Average Concentration of $^{131}I$ in Air—1973
(Units of $10^{-14}$ $\mu Ci/cc$)

| Week Number | LAM's | PAM's | Week Number | LAM's | PAM's |
|---|---|---|---|---|---|
| 1 | 1.8 | 0.7 | 29 | 2.4 | 0.7 |
| 2 | 3.4 | 0.6 | 30 | 2.5 | 0.7 |
| 3 | 7.3 | 0.7 | 31 | 4.4 | 0.8 |
| 4 | 5.5 | 0.8 | 32 | 4.2 | 1.4 |
| 5 | 5.5 | 0.8 | 33 | 3.8 | 0.7 |
| 6 | 3.2 | 0.9 | 34 | 4.9 | 0.9 |
| 7 | 3.7 | 0.9 | 35 | 3.5 | 1.1 |
| 8 | 3.7 | 1.5 | 36 | 14.8 | 0.7 |
| 9 | 11.3 | 1.4 | 37 | 7.9 | 0.8 |
| 10 | 10.3 | 1.0 | 38 | 7.4 | 1.0 |
| 11 | 10.0 | 0.6 | 39 | 3.4 | 1.3 |
| 12 | 9.0 | 0.8 | 40 | 1.1 | 0.5 |
| 13 | 4.0 | 0.9 | 41 | 4.8 | 1.4 |
| 14 | 2.0 | 0.9 | 42 | 5.1 | 1.5 |
| 15 | 3.4 | 0.8 | 43 | 4.6 | 0.8 |
| 16 | 2.3 | 0.6 | 44 | 6.6 | 0.8 |
| 17 | 3.7 | 0.7 | 45 | 3.4 | 0.8 |
| 18 | 6.2 | 0.8 | 46 | 3.6 | 1.0 |
| 19 | 5.9 | 0.7 | 47 | 1.7 | 0.4 |
| 20 | 3.0 | 0.6 | 48 | 2.2 | 0.7 |
| 21 | 4.1 | 0.6 | 49 | 3.3 | 1.3 |
| 22 | 4.1 | 0.6 | 50 | 2.1 | 0.7 |
| 23 | 6.2 | 0.7 | 51 | 2.6 | 0.8 |
| 24 | 4.9 | 1.0 | 52 | 2.9 | 1.2 |
| 25 | 7.3 | 0.9 | | | |
| 26 | 3.0 | 1.1 | | | |
| 27 | 3.2 | 1.0 | | | |
| 28 | 2.8 | 0.9 | Average | 4.7 | 0.9 |

Table 3.2.7 Concentration of $^{131}I$ in Raw Milk—1973
(Units of pCi/l)

| Quarter | Near ORNL | | Remote from ORNL | |
|---|---|---|---|---|
| | Average* | Maximum | Average* | Maximum |
| 1 | 0 - 10.0 | 10 | 0 - 10 | 10 |
| 2 | 0 - 10.1 | 11 | 0 - 10 | 10 |
| 3 | 0 - 10 | 10 | 0 - 10 | 10 |
| 4 | 0 - 10 | 10 | 0 - 10 | 10 |
| Annual | 0 - 10.0 | | 0 - 10 | |

*See text, paragraph 3.2.1(e)

Table 3.2.8 Concentration of $^{90}Sr$ in Raw Milk—1973
(Units of pCi/l)

| Quarter | Near ORNL | | Remote from ORNL | |
|---|---|---|---|---|
| | Average | Maximum | Average | Maximum |
| 1 | 7.3 | 16 | 6.1 | 9 |
| 2 | 9.4 | 17 | 7.3 | 10 |
| 3 | 8.2 | 19 | 5.7 | 12 |
| 4 | 7.2 | 17 | 5.2 | 8 |
| Annual | 8.1 | | 6.1 | |

Table 3.2.9 Discharge of $^{131}I$ from ORNL Stacks—1973*

| Stack Number | Curies | |
|---|---|---|
| | Total for Year | Monthly Average |
| 2026 | 0 | 0 |
| 3039 | 1.46 | 0.12 |
| 3020 | 0 | 0 |
| 7512 | 0 | 0 |
| 7911 | 0.72 | 0.06 |
| Total | 2.18 | 0.18 |

*Data furnished by Operations Division.

Table 3.2.10 Yearly Discharges of Radionuclides to Clinch River
(Curies)

| Year | $^{137}$Cs | $^{106}$Ru | $^{90}$Sr | $^{95}$Zr | $^{95}$Nb | Trans U Alpha | $^{3}$H |
|---|---|---|---|---|---|---|---|
| 1968 | 1.1 | 5 | 2.8 | 0.27 | 0.27 | 0.04 | 9700 |
| 1969 | 1.4 | 1.7 | 3.1 | 0.18 | 0.18 | 0.2 | 12200 |
| 1970 | 2.0 | 1.2 | 3.9 | 0.02 | 0.02 | 0.4 | 9500 |
| 1971 | 0.9 | 0.5 | 3.4 | 0.01 | 0.01 | 0.05 | 8900 |
| 1972 | 1.7 | 0.52 | 6.5 | 0.01 | 0.01 | 0.05 | 10600 |
| 1973 | 2.3 | 0.69 | 6.7 | 0.05 | 0.05 | 0.08 | 15000 |

Σ 9.9

Table 3.2.11 Radioactivity in Clinch River—1973

| Location | Concentration of Radionuclides of Primary Concern Units of $10^{-9}$ μCi/ml | | | | % $MPC_w$ |
|---|---|---|---|---|---|
| | $^{90}Sr$ | $^{137}Cs$ | $^{106}Ru$ | $^{3}H$ | |
| Melton Dam[a] | 0.5 | 0.3 | 0.3 | < 1080 | < 0.24 |
| Clinch River at White Oak Creek[b] | 1.0 | 0.1 | 0.1 | 2134 | 0.49 |
| Gallaher[a] | 1.2 | 0.5 | 0.5 | 2030 | 0.47 |
| Center's Ferry[a] | 1.2 | 0.4 | 0.5 | < 1530 | < 0.62 |

[a]Measured values.

[b]Values given for this location are calculated values based on the concentration of wastes released from White Oak Dam and the dilution afforded by the Clinch River; they do not include radioactive materials (e.g., fallout) that may enter the River upstream from CRM 20.8.

Table 3.2.12 Calculated Percent $MPC_w$ of ORNL Radioactivity Releases in Clinch River Water Below the Mouth of White Oak Creek—1973

| Month | % $MPC_w$ |
|---|---|
| January | 0.46 |
| February | 1.08 |
| March | 0.63 |
| April | 0.72 |
| May | 0.45 |
| June | 0.33 |
| July | 0.18 |
| August | 0.15 |
| September | 0.11 |
| October | 0.18 |
| November | 0.80 |
| December | 0.57 |
| Average | 0.49 |

Table 3.2.13 Radionuclide Content of Clinch River Fish—1973

| Species | pCi/kg Wet Weight | | Estimated % MPI |
|---|---|---|---|
| | $^{90}Sr$ | $^{137}Cs$ | |
| White Crappie | 60 | 1500 | 0.28 |
| Carp | 140 | 540 | 0.45 |

Table 3.2.14 Radiation Background Data—1973

| Station No. | | Location | μR/hr |
|---|---|---|---|
| PAM | 31 | Kerr Hollow | 8.6 |
| | 32 | Midway Gate | 10.7 |
| | 33 | Gallaher Gate | 7.7 |
| | 34 | White Oak Dam | 12.7 |
| | 35 | Blair Gate | 7.0 |
| | 36 | Tumpike Gate | 7.5 |
| | 37 | Hickory Creek | 6.7 |
| | 38 | East EGCR | 6.8 |
| | | Average | 8.4 |
| RAM | 51 | Norris Dam | 5.4 |
| | 52 | Loudoun Dam | 7.2 |
| | 53 | Douglas Dam | 6.9 |
| | 54 | Cherokee Dam | 6.7 |
| | 55 | Watts Bar Dam | 5.9 |
| | 56 | Great Falls Dam | 6.6 |
| | 57 | Dale Hollow Dam | 7.3 |
| | 58 | Knoxville | 11.1 |
| | | Average | 7.1 |

Table 3.2.15 Environmental Monitoring Samples—1973

| Sample Type | Type of Analyses | Number Samples |
|---|---|---|
| Monitoring network filters | Gross beta, autoradiogram | 1497 |
| Gummed paper fallout trays | Gross beta, autoradiogram | 1498 |
| Rainwater | Gross beta | 773 |
| White Oak Dam effluent | Gross beta, radiochemical, gamma spectrometry | 400 |
| Clinch River water | Gross beta, radiochemical, gamma spectrometry | 12 |
| Raw milk | Radiochemical | 352 |
| Potable water | Radiochemical, gamma spectrometry | 4 |
| Soil Samples | Radiochemical, Plutonium and Uranium | 12 |

Table 3.3.1 Portable Instrument Inventory—1973

| Instrument Type | Instruments Added 1973 | Instruments Retired 1973 | In Service Jan. 1, 1974 |
|---|---|---|---|
| G-M Survey Meter | 15 | 23 | 461 |
| Cutie Pie | 10 | 10 | 424 |
| Alpha Survey Meter | 6 | 5 | 264 |
| Neutron Survey Meter | 0 | 0 | 104 |
| Miscellaneous | 0 | 3 | 30 |
| TOTAL | 31 | 41 | 1,283 |

Table 3.3.2 Inventory of Facility Radiation Monitoring Instruments for the Year—1973

| Instrument Type | Installed During 1973 | Retired During 1973 | Total Jan. 1, 1974 |
|---|---|---|---|
| Air Monitor, Alpha | 0 | 3 | 96 |
| Air Monitor, Beta | 0 | 2 | 175 |
| Lab Monitor, Alpha | 0 | 0 | 168 |
| Lab Monitor, Beta | 0 | 3 | 207 |
| Monitron | 0 | 4 | 212 |
| Other | 2 | 2 | 124 |
| TOTAL | 2 | 14 | 982 |

Table 3.3.3 Health Physics Facility Monitoring Instruments
Divisional Allocation at X-10 Site—1973

| ORNL Division | α Air Monitor | β Air Monitor | α Lab Monitor | β Lab Monitor | Monitron | Other | Total |
|---|---|---|---|---|---|---|---|
| Analytical Chemistry | 6 | 14 | 16 | 19 | 15 | 6 | 76 |
| Chemical Technology | 46 | 49 | 64 | 33 | 39 | 33 | 266 |
| Chemistry | 9 | 9 | 19 | 24 | 19 | 8 | 88 |
| Metals and Ceramics | 11 | 6 | 14 | 4 | 5 | 10 | 50 |
| Isotopes | 14 | 28 | 24 | 45 | 53 | 20 | 184 |
| Operations | 2 | 51 | 6 | 29 | 63 | 19 | 170 |
| All Others | 8 | 18 | 25 | 53 | 18 | 28 | 148 |
| TOTAL | 96 | 175 | 168 | 207 | 212 | 124 | 982 |

Table 3.3.4 Calibrations Facility Résumé—1973

| | 1972 | 1973 |
|---|---|---|
| Beta-Gamma | 3,202 | 2,932 |
| Neutron | 370 | 389 |
| Alpha | 838 | 798 |
| Personal Dosimeters | 2,078 | 3,122 |
| Badge Dosimetry Components | 2,746 | 15,650 |

# 4.0 RADIATION AND SAFETY SURVEYS

## 4.1 Laboratory Operations Monitoring

During 1973, Radiation and Safety Surveys personnel assisted the operating groups in keeping the contamination, air concentration and personnel exposure levels well below the established maximum permissible limits. Through seminars, safety meetings and informal discussions with supervision, they assisted in reducing or eliminating a number of problems associated with radiation protection at the Laboratory. The following is a brief description of some of the problems and methods of solution.

### 4.1.1 Radiochemical Pilot Plant Operations, Building 3019

Radiation and Safety Surveys personnel provided assistance in the planning and monitoring of the Chemical Technology Division's Radiochemical Pilot Plant operations in Building 3019. During the year about 150 kg of $^{233}U$ (< 10 ppm $^{232}U$) was processed through solvent extraction and/or ion exchange purification systems and was converted to $UO_2$ for use in the Light Water Breeder Reactor Program. One hundred thirty-seven Radiation Work Permits were certified for the more hazardous operations which included: direct maintenance and modifications of process equipment in grossly contaminated cells; process sampler system repairs; and replacement of a broken gloved box window in the Oxide Conversion Facility. With the cooperation of all personnel involved, hazardous alpha emitters were effectively contained and personnel exposures to gamma radiation from the $^{232}U$ daughters were kept well within permissible limits.

### 4.1.2 Replacement of a Leaking Radiochemical Drain, Building 2026

Radioactive contamination was detected by Radiation and Safety Surveys personnel in the outdoor cabinet housing instrumentation which monitors the hold-up tank for the Building 2026 radiochemical drain system. Further investigation revealed leaks in the drain, serving the hoods and laboratories of Building 2026, which drains to the hold-up tank. Radiation and Safety Surveys personnel provided assistance to the Plant and Equipment and Operations Divisions during subsequent decontamination and repairs. Initial contamination levels in the hold-up tank pit were $> 5 \times 10^5$ $\alpha$ d/m/100 cm$^2$, with radiation fields > 5 R/hr. Contamination levels were reduced by spraying surfaces with pressurized detergent solutions. Contaminated solutions were jetted to a portable tank for disposal. Radiation fields were reduced by filling the tank with water and by spot shielding with lead. Air-supplied plastic suits were used in the pit. In some cases, masks, cloth hoods, and a double suiting of coveralls, rubber gloves, and shoe covers were adequate. Repairs were completed with no significant spread of contamination and without exceeding personnel exposure guides.

### 4.1.3 Renovation of HRLAF Cell #3, Building 3019

Radiation and Safety Surveys personnel provided consultation and on-the-job monitoring to the Analytical Chemistry and Plant and Equipment Divisions for the removal of the alpha containment liner installed in HRLAF Cell #3 in 1963. Contamination levels were > 100 rad/hr (spots) and > $10^5$ $\alpha$ d/m (general). Initial decontamination was performed remotely using master slave manipulators. Final reduction of radiation and contamination levels was achieved by personnel in air-supplied plastic suits, working within a plywood enclosure constructed at the rear opening to the cell. Materials removed were cut to fit into 55-gallon stainless steel drums which were sealed and transferred to the burial ground. Personnel exposures were well within permissible limits and contamination control techniques were effective.

### 4.1.4 Radiation and Safety Surveys Surveillance of Environmental Sciences Division Operations

Radiation and Safety Surveys surveillance and consultation was provided the Environmental Sciences Division for operations in Buildings 2001, 2029, 3013, and 3017. Uptake, elimination, and tracer studies were conducted using about 25 different radioisotopes in μCi and mCi quantities. Some of these, such as $^{14}C$, $^{3}H$, $^{109}Cd$ and $^{85}Sr$, required special detection techniques. Personnel exposure control was effective and no spread of contamination resulted, though somewhat inferior facilities were pressed into service at times.

### 4.1.5 ORIC (Building 6000) Neutron Shielding Studies

Neutron shielding studies were conducted at ORIC using neutrons produced when beams of protons, deuterons, alpha particles and carbon ions were stopped in targets of carbon, aluminum, copper and tantalum. Attenuated and unattenuated dose rate measurements of these neutrons through various thicknesses of concrete were made. The ratios provided by these shielded and unshielded dose rate measurements were translated into half-value thicknesses and the final results of this study will be published in an appropriate document.

### 4.1.6 ORELA (Building 6010) 20-Meter Flight Station Filter System

Work at the 20-meter flight station includes the study of neutron cross-sections of fissionable materials, including gram quantities of various plutonium isotopes. Some experiments utilizing these materials are to be performed inside a large liquid (flammable) scintillator tank which was installed during the year. The recommendation was made that a filter system be installed because of the increased potential for airborne alpha activity. The filter system was installed at the outlet air vent in the 20-meter station and is operating satisfactorily.

4.1.7 Transuranium Research Laboratory, Building 5505

The TRL Radiation and Safety Surveys staff continued their major function of representing the TRL Director in controlling and coordinating TRL facilities and activities pertaining to containment of radioactive materials, industrial safety, and radiation safety. A significant contribution was made in the decontamination of existing facilities and equipment enabling their use in new experimental programs. Assistance continued to be given in planning and conducting procedures relating to experimental facilities.

Construction was begun on a storage room building addition for radioactive materials as recommended by TRL Radiation and Safety Surveys personnel in their preparation of the TRL safety analysis. This facility, which will be completed early in 1974, will not only aid in material inventory and accountability control but will release a significant amount of containment enclosure for more efficient utilization of work space.

4.1.8 Metals and Ceramics Division, Building 4508

Major modifications were made to the ventilation system throughout the building during 1973. The modifications have improved the ventilation with respect to contamination-zoned areas and will definitely aid maintenance personnel during filter change operations.

4.1.9 High-Level Radiochemical Laboratory, Building 4501

(a) Study of Fission Product Distribution in Graphite of Gas-Cooled Reactors – A graphite sleeve from a spent gas-cooled reactor fuel element was sectioned and scanned at Building 4501 to determine the distribution of fission products. Individual segments read up to 1.2 R/hr. Representative sections were machined in a glove box to provide information on the axial distribution of various radioisotopes. The project required extensive Radiation and Safety Surveys coverage in adequately controlling the high radiation levels involved and the extremely dusty nature of the material.

(b) Charcoal Ignition Studies in Iodine Removal Systems – Experiments were conducted in Cell A, Building 4501, to determine the effects of highly radioactive iodine on the desorption from and possible ignition of charcoal under conditions of low air flow. Up to 1200 Ci of $^{130}I$ were used per experiment. Continuous Radiation and Safety Surveys surveillance was provided, and no significant contamination and/or personnel exposure problems were encountered.

(c) Transfer of 5 kCi $^{60}Co$ Irradiation Unit to Storage Cask – Radiation and Safety Surveys personnel assisted in the inactivation of a kilocurie $^{60}Co$ irradiation unit in the basement of Building 4501. The source material was contained in nine capsules which were transferred to a storage cask. External exposures were controlled and minimized through selective shielding of radiation beams.

4.1.10 Radiation and Safety Surveys Assistance on Salient Items Conducted in the Melton Valley Complex

(a) Tower Shielding Facility (TSF), Building 7702 - Badge dosimeters containing TLD's were used in studying dose rates at the outer perimeter fence during reactor operations. The results indicated essentially no change in radiation levels from that existing during non-operational periods.

(b) Health Physics Research Reactor (HPRR), Building 7710 - Radiation and Safety Surveys surveillance was provided during the disassembly and inspection of the reactor following the accidental drop of the unit into the storage pit. Contamination presented no problems and personnel exposures were kept to a minimum.

Survey and monitoring services were also provided during the International Intercomparison Studies Symposium of Nuclear Accident Dosimeters conducted during the year.

(c) Thorium-Uranium Recycle Facility (TURF), Building 7930 - Surveillance and assistance was provided during the transfer, by pneumatic tube, between TURF and TRU of up to 40 mg quantities of $^{252}Cf$. Surveys were also made during the removal and transfer of mg quantities of $^{252}Cf$ and μg quantities of $^{253}Es$ from cell "G" to TRU for sample analysis.

(d) Transuranium Processing Plant (TRU), Building 7920 - The building was shut down for a month to perform some modifications to the processing system and repairs to the equipment. Some entries into the pipe tunnel and cell pits were necessary; however, most of the maintenance was performed remotely because of the extensive levels of alpha contamination and the high dose rates produced by beta, gamma, and neutron radiation. Exposures to personnel were kept well within permissible limits and the contamination was confined to established "C" Zones. More Cf and Es were produced with fewer "campaigns" (process runs) than in the previous year due to upgrading of the target material in the rods irradiated in the HFIR.

(e) High-Flux Isotope Reactor (HFIR), Building 7900 - Assistance and surveillance were provided during the various phases of reactor shutdown, maintenance and operational work. More extensive use was made of the gamma irradiation facilities in the east pool by experimenters, thus utilizing some of the high intensity gamma radiation emitted by spent fuel elements. Dose rates in the range of $5 \times 10^8$ rad/hr were obtained. New and improved methods of transferring contaminated ion exchange resin to the Solid Waste Disposal Area resulted in lower exposure doses to personnel and less release of contamination.

4.1.11 Annual Survey of X-Ray Equipment

The annual X-ray survey was made in which most aspects of X-ray safety were considered. As a result of the survey, recommendations were made to repair the defective interlock system on one walk-in facility and to replace defective warning lights on four other units. There are 74 X-ray units registered.

In an effort to improve the safety of the X-ray machines and to comply with the increased Federal requirements, all available diagrams of safety-related circuits and interlock systems for X-ray units at the Laboratory have been turned over to the Instrumentation and Controls Division for review and recommendations. As a result of this program, light failure alarms are being installed on most of the X-ray diffraction units. The light failure alarm was designed by an individual in the Instrumentation and Controls Division and will cause a buzzer to sound if a warning light fails. Twelve of these units were installed during the year.

### 4.1.12 Survey of Microwave-Generating Equipment

The canteen and lunchroom microwave ovens were surveyed quarterly to determine if there were microwave leakage problems. All the units surveyed indicated leakage rates well below Federal limits and showed no tendency to change during the year. A new, more sensitive microwave survey instrument was obtained which allows a more accurate determination of any change in small leakage rates.

### 4.1.13 Elmo Bumpy Torus Experiment, Building 9201-2, Y-12

The Elmo Bumpy Torus Experiment is closely modeled after existing stable, steady-state, high-beta, hot electron plasmas produced in open-ended traps with electron cyclotron heating. The machine was operational for three months during the fall of 1973. Operation was limited to the use of four of the 24 magnetic cavities. This restriction was necessary due to the lack of shielding over the top of the machine, which allowed X-radiation reflection from the building ceiling. After the equipment was shut down, three-inch lead shielding was installed over the top. During the period of time that the machine was operational, Radiation and Safety Surveys surveillance was provided and personnel exposures were maintained well within daily permissible limits.

### 4.1.14 Radiation Surveys Made Off-Area

Radiation and Safety Surveys, on authorized request, also furnished survey coverage for a number of off-area projects. Following is a brief description of some of the items covered.

(a) Radiation and Safety Surveys Assistance at Lyons, Kansas - During the salt vault experiments, continuous monitoring was provided by a health physicist from ORNL when radioactive materials were being placed in the mine and also when they were being removed. During these operations, personnel, equipment and operating areas were closely monitored to prevent accidental spread of radioactive contamination.

Since the Salt Mine Repository experiments have been concluded, a detailed survey was performed during the month of September to assure that no significant amounts of radioactivity were left in the areas as a result of the AEC-ORNL operations. Approximately 130 man-hours were required to survey all areas. No radioactivity was found which exceeded the natural background of the area.

(b) Radiation and Safety Surveys Coverage of the Radio-Isotopic Sand Tracer Project, New York Harbor - During November, 1973, a representative of the Radiation and Safety Surveys Section provided on-the-job surveillance for the "RIST Program" planned by the National Oceanographic and Atmospheric Administration (NOAA). The test was conducted from New York Harbor and consisted of sand tagged with $^{198}$Au being placed at three pre-determined locations near the outer edge of the continental shelf. By tracing the movement of the sand with a submergible scintillation counter a transfer of the Harbor sediments was plotted. The close cooperation of all groups concerned (NOAA, ORNL, and ship's crew) resulted in excellent control of personnel exposure and radioactive contamination.

(c) Radiation and Safety Surveys Coverage of the Sand Tracer Projects, Ocean Side and Point Mugu, California - A representative of the Radiation and Safety Surveys Section acted as a project health physicist at the Radio-Isotopic Sand Tracer Tests conducted by the U. S. Corps of Engineers. The tests were conducted at Ocean Side, California, and at Point Mugu, California. The test involved placing radioactive sand (tagged with $^{198-199}$Au) offshore and tracing its movement along the ocean floor by the use of a specially designed radiation detection system. The Radiation and Safety Surveys representative provided on-the-job surveillance and, in addition, helped train a member of the U. S. Corps of Engineers in the fundamentals of applied health physics survey techniques. The tests were completed without any significant contamination and/or exposure problems.

## 4.2 Unusual Occurrences

Radiation incidents are classified according to a severity index system developed over the past several years.[4] The method serves to index unusual occurrences according to degree of severity and permits a system of analysis regarding Applied Health Physics and Safety practices among Laboratory operations.

During 1973, there were 10 unusual occurrences recorded which represents a decrease of one from the number reported for 1972 (Table 4.2.1, page 42). The number for 1973, 10, is the same as the five-year average for the years 1969 through 1973. The frequency rate of unusual occurrences among Laboratory divisions involved (Table 4.2.2, page 43) is known to vary in relationship to the quantity of radioactive materials handled, the number of radiation workers involved, and the radiation potential associated with a particular operation or facility.

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[4] See ORNL-3665, Applied Health Physics Annual Report for 1963, pp. 14-15.

Three of the incidents reported during 1973 involved area contamination that was handled by the regular work staff without appreciable production or program loss. Four occurrences involved personnel contamination requiring decontamination under medical supervision, and three occurrences were concerned with potential exposures and contamination problems that might have been more serious under less favorable circumstances.

### 4.3 Laundry Monitoring

There were approximately 337,300 articles of wearing apparel monitored at the Laundry during 1973. Approximately 14 percent were found contaminated. Of 161,348 khaki garments monitored during the year, only 83 were found contaminated.

A total of 6,555 full-face respirators and 4,912 cannisters were monitored during the year, and of this number 597 required further decontamination after the first cleaning cycle.

Table 4.2.1 Unusual Occurrences Summarized for the 5-Year Period Ending with 1973

| | 1969 | 1970 | 1971 | 1972 | 1973 |
|---|---|---|---|---|---|
| Number of Unusual Occurrences Recorded . . . . . . . . . | 12 | 9 | 10 | 11 | 10 |
| A. Number of incidents of minor consequence involving personnel exposure below MPE limits and requiring little or no cleanup effort . . . . . . . . . . . . . . . . . . . . . . . . . . . . . | 4 | 2 | 1 | 2 | 7 |
| B. Number of incidents involving personnel exposure above MPE limits and/or resulting in special cleanup effort as the result of contamination . . . . . . . . . . . . . . . . . . . . . | 8 | 7 | 9 | 9 | 3 |
| 1. Personnel Exposures . . . . . . . . . . . . . . . . . . | 6 | 1 | 3 | 4 | 4 |
| a. Nonreportable overexposures with minor work restrictions imposed . . . . . . . . | 6 | 1 | 3 | 4 | 4 |
| b. Reportable overexposures with work restrictions imposed . . . . . . . . . . . . | 0 | 1 | 0 | 0 | 0 |
| 2. Contamination of Work Area . . . . . . . . . . . . | 8 | 6 | 9 | 9 | 3 |
| a. Contamination that could be handled by the regular work staff with no appreciable departmental program loss . . . . . . . . . . . . . | 7 | 5 | 8 | 8 | 3 |
| b. Required interdepartmental assistance with minor departmental program loss . . . . . . . . . . . . . . . . . . . . . . . . | 1 | 1 | 1 | 1 | 0 |
| c. Resulted in halting or temporarily deterring parts of the Laboratory program . . . | 0 | 0 | 0 | 0 | 0 |

Table 4.2.2 Unusual Occurrence Frequency Rate within the Divisions for the 5-Year Period Ending with 1973

| Division | No. of Unusual Occurrences 1969 | 1970 | 1971 | 1972 | 1973 | 5-Year Total | Percent Lab. Total (5-Year Period) |
|---|---|---|---|---|---|---|---|
| Analytical Chemistry | 1 | | 1 | 1 | | 3 | 5.8 |
| Chemical Technology | 4 | 2 | 1 | 1 | 4 | 12 | 23.1 |
| Chemistry | | | 1 | 1 | | 2 | 3.8 |
| Environmental Sciences | | | | | 1 | 1 | 1.9 |
| Health Physics | | | | | 1 | 1 | 1.9 |
| Inspection Engineering | | 1 | | | | 1 | 1.9 |
| Isotopes | 2 | 3 | 4 | 5 | | 14 | 27.0 |
| Metals and Ceramics | 1 | 1 | 1 | | | 3 | 5.8 |
| Operations | 2 | 2 | 2 | 2 | 3 | 11 | 21.2 |
| Physics | | | | 1 | | 1 | 1.9 |
| Reactor Chemistry | | | | | 1 | 1 | 1.9 |
| Reactor | 1 | | | | | 1 | 1.9 |
| Solid State | 1 | | | | | 1 | 1.9 |
| TOTALS | 12 | 9 | 10 | 11 | 10 | 52 | 100.0 |

# 5.0 SAFETY ENGINEERING AND SPECIAL PROJECTS

The safety record for 1973 was one of the best in the history of the Laboratory. There were only two Disabling Injuries. Only once since the inception of the Carbide contract (1948) has there been fewer than two Disabling Injuries in a calendar year and only one other year (1969) when there has been only two Disabling Injuries.

## 5.1 Accident Analyses

The Disabling Injury frequency rate for 1973 was 0.33, as compared with a frequency rate of 1.08 for 1972. The Disabling Injury history for ORNL for the seven-year period, 1967-1973, is shown in Table 5.1.1, page 46. Frequency rates since Union Carbide began operating ORNL in 1948 are shown in Table 5.1.2, page 47.

Fifteen divisions did not have a Serious or Disabling Injury in 1973. Only seven divisions have experienced one or more Disabling Injuries since 1970. Serious and Disabling Injury data for ORNL divisions are shown in Table 5.1.3, page 48.

A comparison of injury data for ORNL, Paducah, Y-12, and ORGDP for 1973 is shown in Table 5.1.4, page 49. Tables 5.1.5, 5.1.6, page 50, and 5.1.7, page 51, present 1973 ORNL injury data according to accident type, nature of injury and part of body injured.

## 5.2 Summary of Disabling Injuries

Following are summaries of the two Disabling Injuries experienced at ORNL in 1973:

Date of Injury - 4/26/73

A carpenter was standing backwards on the third step of a six-foot stepladder. He was using the claw of his hammer to remove molding from a door. The molding broke and he went over the top of the ladder backwards. He was hospitalized with injuries consisting of a contusion of the lumbar area, a contusion of the post cervical area, small abrasions on the neck and elbow, and a bruised kidney. Time loss: 17 days.

Date of Injury - 7/30/73 (Classified as Disabling 10/29/73)

An equipment operator was using a farm-type tractor to mow near a fence. He was looking down at a rear wheel to avoid a boulder when the right front wheel struck a fence post, causing the steering wheel to spin. The jamming, twisting action to his right shoulder produced a moderately severe strain. This was classified as a Serious

Injury, but the employee continued to have pain in his shoulder. On October 29, 1973, exploratory surgery was performed, and it was found that the employee had rotator cuff disease, secondary to traumatic injury. He returned to work on March 4, 1974. Time loss: 126 days.

## 5.3 Safety Awards

ORNL employees worked three periods of 120 days without a Disabling Injury during 1973. These periods were:

December 12, 1972 - April 10, 1973

April 27, 1973 - August 24, 1973

August 25, 1973 - December 22, 1973

Three drawings were held to cover these award periods. There were 107 winners in the first drawing, 96 winners in the second drawing, and 358 winners in the third drawing. Since ORNL achieved the Nuclear Division safety goal of a Disabling Injury frequency rate of less than 0.5 ($2.00/employee) and since the whole Nuclear Division achieved the UCC-ND safety goal of a Disabling Injury frequency rate of less than 0.5 ($2.00/employee), each ORNL employee received a $10.00 General Fund safety award gift for its 1973 safety performance.

Table 5.1.1 Disabling Injury History—ORNL (1967-1973)

| | 1967 | 1968 | 1969 | 1970 | 1971 | 1972 | 1973 |
|---|---|---|---|---|---|---|---|
| Number of Injuries | 4 | 1 | 2 | 5 | 4 | 7 | 2 |
| Labor Hours (Millions | 8.0 | 7.8 | 7.5 | 6.6 | 6.5 | 6.5 | 6.0 |
| Frequency Rate | 0.50 | 0.13 | 0.27 | 0.76 | 0.61 | 1.08 | 0.33 |
| Days Lost or Charged | 1816 | 60 | 67 | 577 | 1944 | 337 | 143 |
| Severity Rate | 226 | 8 | 9 | 88 | 298 | 52 | 24 |

Table 5.1.2 ORNL Disabling Injury Frequency Rates Since Inception of Carbide Contract Compared with Frequency Rates for NSC*, AEC and UCC

| Year | ORNL | NSC | AEC | UCC |
|---|---|---|---|---|
| 1948 | 2.42 | 11.49 | 5.25 | 5.52 |
| 1949 | 1.54 | 10.14 | 5.35 | 4.91 |
| 1950 | 1.56 | 9.30 | 4.70 | 4.57 |
| 1951 | 2.09 | 9.06 | 3.75 | 4.61 |
| 1952 | 1.39 | 8.40 | 2.70 | 4.37 |
| 1953 | 1.43 | 7.44 | 3.20 | 3.61 |
| 1954 | 0.79 | 7.22 | 2.75 | 3.02 |
| 1955 | 0.59 | 6.96 | 2.10 | 2.60 |
| 1956 | 0.55 | 6.38 | 2.70 | 2.27 |
| 1957 | 1.05 | 6.27 | 1.95 | 2.41 |
| 1958 | 1.00 | 6.17 | 2.20 | 2.21 |
| 1959 | 1.44 | 6.47 | 2.15 | 2.16 |
| 1960 | 0.94 | 6.04 | 1.80 | 1.92 |
| 1961 | 1.55 | 5.99 | 2.05 | 2.03 |
| 1962 | 1.45 | 6.19 | 2.00 | 2.28 |
| 1963 | 1.55 | 6.12 | 1.60 | 2.10 |
| 1964 | 1.07 | 6.45 | 2.05 | 2.20 |
| 1965 | 2.34 | 6.53 | 1.80 | 2.40 |
| 1966 | 0.64 | 6.91 | 1.75 | 2.57 |
| 1967 | 0.50 | 7.22 | 1.55 | 2.06 |
| 1968 | 0.13 | 7.35 | 1.27 | 2.24 |
| 1969 | 0.27 | 8.08 | 1.52 | 2.49 |
| 1970 | 0.76 | 8.87 | 1.28 | 2.27 |
| 1971 | 0.61 | 9.37 | 1.44 | 2.05 |
| 1972 | 1.08 | 10.17 | 1.40 | 1.73 |
| 1973 | 0.33 | — | 1.36 | 1.50 |

*National Safety Council (NSC), all industries.

Table 5.1.3 Injury Statistics by Division—1973

| Division | Medical Treatment Cases | Serious Injuries No. | Serious Injuries Freq. | Disabling Injuries Number | Disabling Injuries Freq. | Disabling Injuries Sev. | Exposure Hours (In Millions) |
|---|---|---|---|---|---|---|---|
| Analytical Chemistry | 7 | 0 | 0 | 0 | | | .202 |
| Chemical Technology | 17 | 1 | 2.30 | 0 | | | .435 |
| Chemistry | 8 | 0 | 0 | 0 | | | .144 |
| Director's | 7 | 1 | 8.66 | 0 | | | .116 |
| Environmental Sciences | 18 | 2 | 9.59 | 0 | | | .201 |
| Health Physics | 9 | 0 | 0 | 0 | | | .303 |
| Instr. and Controls | 29 | 1 | 2.30 | 0 | | | .434 |
| Computer Sciences | 4 | 0 | 0 | 0 | | | .346 |
| Metals and Ceramics | 22 | 3 | 7.81 | 0 | | | .384 |
| Neutron Physics | 2 | 0 | 0 | 0 | | | .125 |
| Physics | 8 | 2 | 10.44 | 0 | | | .192 |
| Reactor | 1 | 0 | 0 | 0 | | | .013 |
| Reactor Chemistry | 1 | 0 | 0 | 0 | | | .046 |
| Solid State | 2 | 0 | 0 | 0 | | | .126 |
| Engineering | 4 | 0 | 0 | 0 | | | .251 |
| Finance and Materials | 6 | 0 | 0 | 0 | | | .128 |
| Health | 0 | 0 | 0 | 0 | | | .049 |
| Information | 8 | 1 | 4.68 | 0 | | | .214 |
| Isotopes | 16 | 2 | 11.09 | 0 | | | .168 |
| Laboratory Protection | 12 | 0 | 0 | 0 | | | .136 |
| Operations | 32 | 5 | 15.07 | 0 | | | .331 |
| Personnel | 8 | 0 | 0 | 0 | | | .130 |
| Plant and Equipment | 349 | 16 | 12.04 | 2 | 1.51 | 108 | 1.329 |
| Envr. Program | 0 | 0 | 0 | 0 | | | .038 |
| Insp. Engineering | 6 | 0 | 0 | 0 | | | .064 |
| MAN | 2 | 1 | 16.91 | 0 | | | .059 |
| EISO | 1 | 0 | 0 | 0 | | | .056 |
| PLANT TOTAL | 579 | 35 | 5.81 | 2 | 0.33 | 24 | 6.020 |

Table 5.1.4 Four-Plant Tabulation of Injuries—1973

| Plant | Labor Hours (Millions) | Disabling | | | | Serious | |
|---|---|---|---|---|---|---|---|
| | | Number of Injuries | Frequency Rate | Days Lost or Charged | Severity Rate | Number of Injuries* | Frequency Rate |
| ORNL | 6.0 | 2 | 0.33 | 143 | 24 | 35 | 5.81 |
| ORGDP | 5.6 | 5 | 0.88 | 373 | 66 | 86 | 15.12 |
| Y-12 | 12.2 | 4 | 0.33 | 133 | 11 | 99 | 8.42 |
| Paducah | 2.3 | 0 | 0 | 0 | 0 | 19 | 7.97 |

*Includes the number of Disabling Injuries.

Table 5.1.5 Number of Accidents by Types

| Type of Accident | Number of Accidents |
|---|---|
| Struck Against | 181 |
| Struck By | 144 |
| Slip, Twist, Overexertion | 86 |
| Caught In, On, or Between | 52 |
| Fall, Same Level | 29 |
| Fall, Different Level | 7 |
| Contact, Temperature Extremes | 15 |
| Inhalation, Absorption, Ingestion | 11 |
| Electrical | 2 |
| Other | 55 |
| TOTAL | 582 |

Table 5.1.6 Number of Accidents by Nature of Injury

| Nature of Injury | Number of Accidents |
|---|---|
| Laceration, Puncture | 205 |
| Contusion, Abrasion | 120 |
| Strain | 80 |
| Conjunctivitis | 15 |
| Sprain | 21 |
| Burn (Temperature) | 31 |
| Burn (Chemical) | 6 |
| Burn (Flash) | 0 |
| Fracture, Dislocation | 7 |
| Hernia | 3 |
| Other | 94 |
| TOTAL | 582 |

Table 5.1.7 Number of Accidents Relative to Part of Body Injured

| Body Area | Percentage | Total Injuries |
|---|---|---|
| Head | 7.7 | 45 |
| Eyes | 6.4 | 37 |
| Shoulder-Chest | 5.0 | 29 |
| Back | 8.4 | 49 |
| Arms | 9.6 | 56 |
| Hands | 9.6 | 56 |
| Fingers | 33.5 | 195 |
| Lower Trunk | 3.4 | 20 |
| Legs | 9.5 | 55 |
| Feet | 5.3 | 31 |
| Toes | .7 | 4 |
| Other | .9 | 5 |
| TOTAL | 100.0 | 582 |

# 6.0 INFORMATIONAL ACTIVITIES

## 6.1 Visitors and Training Groups

During 1973 there were 98 visitors to Applied Health Physics and Safety Sections, as individuals or in groups, for training purposes. Included in this number were visitors from nine foreign countries.[5] Table 6.1.1 is a listing of training groups which consisted of four or more persons.

Table 6.1.1 Training Groups in Applied Health Physics and Safety Facilities during 1973

| Facility | Number | Training Period |
|---|---|---|
| AEC Trainees | 5 | 5/21/73 - 8/17/73 |
| University of Arkansas | 4 | 5/7/73 - 5/9/73 |
| Davidson College | 12 | 2/22/73 - 2/23/73 |
| ORAU Health Physics Technology Training Program | 8 | 5/21/73 - 10/9/73 |

## 6.2 Publications and Papers

H. M. Butler and J. K. Bair, "Neutron Yield from a Small High Purity $^{238}PuO_2$ Source", Nuclear Technology, Vol. 19, September, 1973.

H. M. Butler, K. M. Wallace, and C. B. Fulmer, "Half-Value Thicknesses of Ordinary Concrete for Neutrons from Cyclotron Targets", Health Physics, Vol. 24, pp. 438-439, 1973.

H. M. Butler, K. M. Wallace, and C. B. Fulmer, "Half-Value Thickness Measurements of Ordinary Concrete for Neutrons from Cyclotron Targets", presented at the 1973 Annual AIHA Conference, Boston, Massachusetts, May 20-25, 1973.

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[5] Korea, Bangladesh, Iran, Taiwan, Hungary, Netherlands, Czechoslovakia, Greece, and Brazil.

D. M. Davis, "Industrial Safety and Special Assignments", presented at the Biomedical Program Directors Meeting at ORNL, April 9-10, 1973.

D. M. Davis, Applied Health Physics and Safety Annual Report for 1972, ORNL-4894, September, 1973.

Environmental Monitoring Report, United States Atomic Energy Commission, Oak Ridge Facilities, Calendar Year 1972, UCC-ND-244, Office of Safety and Environmental Protection (E. D. Gupton, contributor), March 26, 1973.

Environmental Monitoring at Major U. S. Atomic Energy Commission Contractor Sites, Calendar Year 1972, WASH 1259, Division of Operational Safety, USAEC (E. D. Gupton, contributor), August, 1973.

E. D. Gupton, Methods and Procedures for Internal Radiation Dosimetry at ORNL, January 1973, ORNL CF-73-1-65, January 1, 1973.

E. D. Gupton, "Radiation Monitoring", presented at the Biomedical Program Directors Meeting at ORNL, April 9-10, 1973.

W. W. Parkinson, "The Effect of Polar Groups on the Post-Irradiation Conductivity of Polystyrene", presented at the Second Cairo Solid State Conference, organized by the American University in Cairo in cooperation with Ein Shams University, and sponsored by the U. S. National Science Foundation, April 21-26, 1973.

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